Growth references for height, weight and body mass index of twins aged 0–2.5 years.

Dommelen, P.; de Gunst, M.C.M.; van der Vaart, A.W.; van Buuren, S.; Boomsma, D.I.

published in
Acta Paediatrica
2008

DOI (link to publisher)
10.1111/j.1651-2227.2008.00853.x

document version
Publisher's PDF, also known as Version of record

ACTA PÆDIATRICA
PROMOTING CHILD HEALTH

Acta Pædiatrica ISSN 0803–5253

REGULAR ARTICLE

Growth references for height, weight and body mass index of twins aged 0–2.5 years

Paula van Dommelen (Paula.vanDommelen@tno.nl)[1,2], Mathisca de Gunst[1], Aad van der Vaart[1], Stef van Buuren[2,3], Dorret Boomsma[4]

1.Department of Mathematics, Free University, Amsterdam, the Netherlands
2.Department of Statistics, TNO Quality of Life, Leiden, the Netherlands
3.Department of Methodology & Statistics, University of Utrecht, Utrecht, the Netherlands
4.Department of Biological Psychology, Free University, Amsterdam, the Netherlands

Keywords
Child, Growth, Growth charts, Twins

Correspondence
Paula van Dommelen, Department of Statistics, TNO Quality of Life, P.O. Box 2215, Leiden, The Netherlands.
Tel: +31-715181728 |
Fax: +31-715181920 |
Email: Paula.vanDommelen@tno.nl

Received
6 December 2007; revised 14 March 2008; accepted 14 April 2008.

DOI:10.1111/j.1651-2227.2008.00853.x

Abstract
Aim: To determine the size of the growth deficit in Dutch monozygotic and dizygotic twins aged 0–2.5 years as compared to singletons and to construct reference growth charts for twins.
Methods: Growth of twins was studied using longitudinal data on over 4000 twins aged 0–2.5 years of the Netherlands Twin Register. The LMS method was used to obtain growth references for length/height, weight, and body mass index (BMI) for twins.
Results: During the first 2.5 years of age, differences in length/height and weight between twins and singletons decrease but do not disappear. BMI of twins deviates less than that of singletons. Approximately half of the growth retardation from birth until 1.5 years of age was attributable to gestational age. Between 1.5 years and 2.5 years of age, this difference was reduced to one-third. Thus, a substantial part of the growth difference could not be explained by gestational age.

Conclusion: During the first 2.5 years of life, there is a difference in growth between twins and singletons. Twins catch up in their body size, i.e. they grow faster after birth, but do not yet achieve the same height and weight till they reach 2.5 years of age. We recommend the use of the growth references for twins.

INTRODUCTION

Monitoring children's height is a standard procedure in many countries. Children's height is measured in order to diagnose abnormal height growth rates and to monitor the results of any treatment for such conditions. Weight is another important growth parameter, which provides information about the individual's nutritional status. The Quetelet Index (body mass index (BMI) = kg/m^2) is used to identify cases of overweight or underweight and to monitor nutritional status. The increase in height and weight during infancy has a strong correlation with gestational age and with the growth during pregnancy. A study on Australian twins and singletons concluded that the twins exhibit slower growth in comparison to singletons from week 26 of pregnancy until birth (1). In addition, twin pregnancies were about 3 weeks shorter than the singleton pregnancies, resulting in low birth weight. The same was found in Dutch twins, where the mean birth weight of twins was almost 1 kg less than that of singletons (2). Belgian twins showed a reduction in weight gain from week 32 of pregnancy onwards. For height this effect was not seen until week 39 (3). The Belgian study signalled that height and weight of twins cannot be compared with those of singletons. Also, the American twins were found to lag at birth, both in terms of height and weight. They rapidly caught up in weight during the first 3 months, whereas height took much longer (4). The literature cited above suggests that during infancy, the growth pattern of twins differs from that of singletons. Therefore, there is need for special growth charts for twins. In order to fill this gap, we investigated the size of the growth deficit in Dutch monozygotic and dizygotic twins from birth to 2.5 years of age. We compared longitudinal data from Dutch twins with reference charts for the Netherlands dating from 1997 (5,6). Reference charts for twins were constructed. Abnormalities in the growth of twins can now be identified more effectively with these new charts than would be possible by using the standard references.

Abbreviations
SDS, standard deviation score; BMI, body mass index; NTR, Netherlands Twin Register; MZB, monozygotic boys; MZG, monozygotic girls; DZB, dizygotic boys; DZG, dizygotic girls; L, skewness curve; M, the median curve; S, the coefficient of variation curve; SMOCC, social medical survey of children attending child health clinics.

PATIENTS AND METHODS

The data were derived from the Netherlands Twin Register (NTR) at VU University, Amsterdam. Longitudinal length/height and weight measurements were obtained in post-natal clinics between birth and approximately 2.5 years of age (7–9) of the twins born during the period 1986–1992. A child was included if it was measured on at least one occasion between birth and 2.7 years of age and suffered no severe handicaps. Twins were analyzed as two separate individuals (10).

For length/height, the data consisted of 1420 monozygotic boys (MZB), 1580 monozygotic girls (MZG), 2669 dizygotic boys and boys from boy–girl twin pairs (DZB) and 2623 dizygotic girls and girls from boy–girl twin pairs (DZG). For weight, we had 1428 MZB, 1583 MZG, 2677 DZB and 2630 DZG. For BMI, there were 1418 MZB, 1577 MZG, 2665 DZB and 2618 DZG. Most of the children were measured on 9–12 occasions.

The LMS method was used to determine the reference lines for length/height, weight and BMI (11). The principle behind this method is that, following a suitable transformation, the data show a standard normal distribution. We refer to a transformed data point as a standard deviation score (SDS). In the LMS method, this transformation involves the use of three age-dependent curves. These are the skewness curve (L), the median curve (M), and the coefficient of variation curve (S). In order to obtain smooth and accurate L, M, and S curves, the method uses the standard likelihood function with a penalty term for lack of smoothness (maximum penalized likelihood) (12). Worm plots were used to check the normality of the SDS (13). The LMS Pro program (version 1.16, dated 15 April 2002) was used for the calculations involved in the LMS method (14). The worm plots were made by using S-plus 2000. For length/height and weight, age was scaled in the way it expanded during periods of rapid growth and compressed during periods of slow growth. For BMI, a power transformation was used, using 0.33 (for boys) and 0.25 (for girls) with zero offset (13). Children with retarded growth are likely to visit post-natal clinics more often. In order to prevent short children from becoming over-represented in the LMS analyses a weighting factor was calculated for all measurements. This weighting factor was defined per child as the inverse of the number of occasions on which that child was measured. When L, M and S references for twins are available, each measurement can be converted into SDS. SDS of measurement x is calculated as $((x/M)^L - 1)/LS$ (when $L \neq 0$) or $\ln(x/M)/S$ (when $L = 0$). This SDS expresses the measurement in relation to twins in units of standard deviations above or below the median and is useful to detect trends in both mean and variability. Growth anomalies in twins were calculated in relation to the Dutch 1997 references.

To investigate the deficit of SDS corrected for gestational age, we applied the prenatal (intrauterine) reference curve according to Niklasson et al. in preterm infants (15). This curve was used to express SDS till the age corresponding with 40 weeks of gestation. Between 40 and 42 weeks an interpolation between this curve and that of the 1997 Dutch references was used. From 42 weeks of gestation till the age of 2 years, SDS was calculated on ages corrected for gestation, using the 1997 Dutch references. The SDS for the term infants was based on the 1997 Dutch references.

RESULTS

Table 1 contains mean length/height, weight and BMI on the SDS scale for various age groups. During the first 6 months , the mean length and weight deficit was equal to −1.3 to −1.4 SDS (10th percentile) for monozygotic twins in relation to the reference population of singletons. For dizygotic twins, length and weight deficit ranged from −1.2 to −1.3 SDS. Twins catch up part of the growth deficit in later life. Between 0.5 and 1.5 years, mean SDS had increased to −0.6 SDS (approximately the 25th percentile), and between 1.5 and 2.5 years it reached approximately −0.3 SDS (approximately the 35th percentile). At that point, dizygotic girls, in particular, had nearly reached the reference level. For BMI, mean SDS was substantially closer to the mean of the reference population than for height and weight (see Table 1).

Table 2 shows the magnitude of the contribution made by gestational age relative to the standard reference population. For the twins, whose age of gestation was known to range from 39 to 41 weeks, i.e. for term births, (954 children),

Table 1 Mean standard deviation score (SDS) of Dutch twins for length/height, weight and BMI relative to the 1997 Dutch references

	Monozygotic		Dizygotic		
	Boys	Girls	Boys	Girls	Total
Length/height					
< 0.5 year###	−1.37 (1.17)	−1.31 (1.26)	−1.20 (1.13)	−1.16 (1.18)	−1.24 (1.18)
0.5–1.4 year##	−0.59 (0.96)	−0.63 (1.01)	−0.56 (0.99)	−0.54 (1.01)	−0.57 (0.99)
1.5–2.5 year#	−0.33 (1.01)	−0.33 (1.07)	−0.33 (1.01)	−0.22 (1.04)	−0.30 (1.03)
Weight					
< 0.5 year###	−1.43 (1.12)	−1.37 (1.24)	−1.33 (1.09)	−1.25 (1.15)	−1.33 (1.15)
0.5–1.4 year	−0.66 (0.91)	−0.57 (1.00)	−0.65 (0.93)	−0.54 (0.96)	−0.60 (0.95)
1.5–2.5 year	−0.36 (0.95)	−0.26 (1.03)	−0.31 (0.96)	−0.22 (0.97)	−0.28 (0.98)
BMI					
< 0.5 year	−0.57 (1.01)	−0.56 (1.01)	−0.59 (1.02)	−0.53 (0.95)	−0.56 (0.99)
0.5–1.4 year	−0.35 (0.90)	−0.18 (0.94)	−0.36 (0.96)	−0.22 (0.88)	−0.28 (0.92)
1.5–2.5 year	−0.10 (0.96)	−0.03 (1.01)	−0.05 (0.99)	−0.08 (1.02)	−0.07 (1.00)

Note: Statistical significant between monozygotic and dizygotic twins: ### $p < 0.005$, ##$p < 0.001$ (girls), #$p < 0.01$ (girls).
The standard deviation is shown in parentheses.

Table 2 Mean standard deviation score (SDS) of Dutch twins whose age of gestation was known to range from 39 to 41 weeks, for length/height, weight and BMI in relation to the 1997 Dutch references

	Length/height SDS	Weight SDS	BMI SDS
< 0.5 year	−0.59 (0.89)	−0.73 (0.89)	−0.39 (0.91)
0.5–1.4 year	−0.31 (0.93)	−0.39 (0.88)	−0.21 (0.86)
1.5–2.5 year	−0.10 (1.01)	−0.09 (0.93)	0.03 (0.98)

The standard deviation is shown in parentheses.

mean SDS was calculated for three age groups. We observed a deviation of −0.6 to −0.7 SDS for the length and the weight throughout the first 6 months. One year later, that deviation was −0.3 to −0.4 SDS. That means that approximately half of the size of the deviation seen throughout the first 18 months can be attributed to gestational age. During the period from 18 months to 2.5 years, this was reduced to one-third. When applying the prenatal reference curve for the preterm infants and the 1997 Dutch references for the term infants, the mean (SD) length/height SDS corrected for gestational age was −0.52 (1.04) for age group <0.5 year, −0.25 (0.97) for age group 0.5–1.5 years and −0.17 (1.03) for age group 1.5–2.5 years, and for weight was −0.63 (1.08) for age group <0.5 year, −0.37 (0.97) for age group 0.5–1.5 years and −0.20 (0.99) for age group 1.5–2.5 years. This is in agreement with the results shown in Table 2. Accordingly, a correction for premature birth alone will not be enough to render the growth of twins comparable to the growth of singletons.

The difference in length and weight from birth to 6 months of age between monozygotic and dizygotic twins was small but statistically significant in both girls and boys (see Table 1). This difference in SDS varied between 0.10 and 0.17. This is a relatively small difference and therefore in clinical practice it is recommended to use the reference charts based on the dizygotic twins, as most twins are dizygotic (see Figs. 1–2). However, if a computer-based system is available in child health care, we recommend to use the L, M, S values for length and weight for both monozygotic and dizygotic twins, as length and weight of monozygotic twins are systematically lesser than that of dizygotic twins (see Table 3).

It is noteworthy that our twin length references are skewed to the left (i.e. L > 1), while length references are usually normally distributed (e.g. the Dutch 1980 or 1997). Furthermore, this left skewness disappears with age in the monozygotic twins, but remains unchanged in the dizygotes. This might indicate that the monozygic twins who are born short are more likely to catch up over a period of time than the dizygotic twins. We tested this by comparing the growth velocity of height between monozygotic and dizygotic twins born short (< −1 SDS using twin references) on a subpopulation of twins previously described in van Dommelen et al. (2004) (16). We found that monozygotic twins who were born short had a slightly higher (+0.29 to +0.40) growth velocity compared to dizygotic twins, although not statistically significant. Thus, the analysis did not provide evidence in favour of the suggestion that monozygtic twins are more likely to catch up.

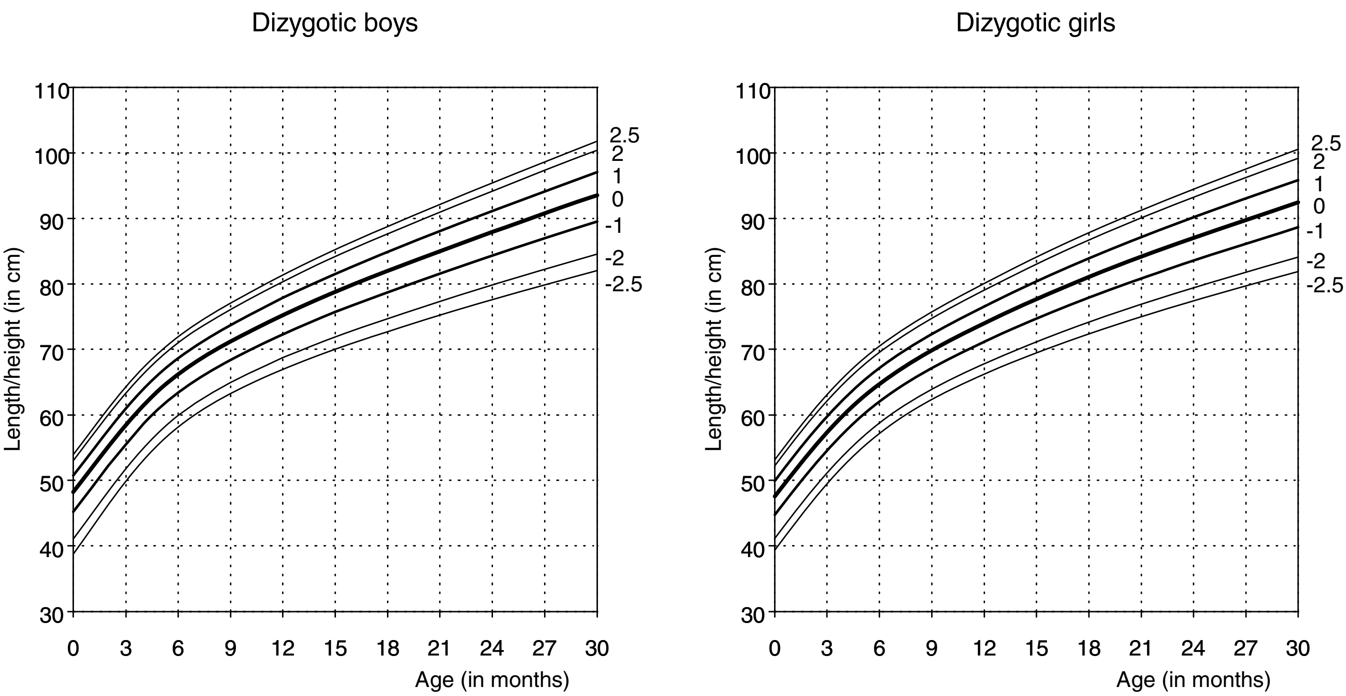

Figure 1 Reference charts for length/height of twins in the Netherlands: dizygotic boys and girls from birth to 2.5 years of age; the following curves are shown −2.5 SDS (= P0.6), −2 SDS (= P2), −1 SDS (= P16), 0 SDS (= P50 = median), 1 SDS (= P84), 2 SDS (= P98) and 2.5 SDS (= P99.4).

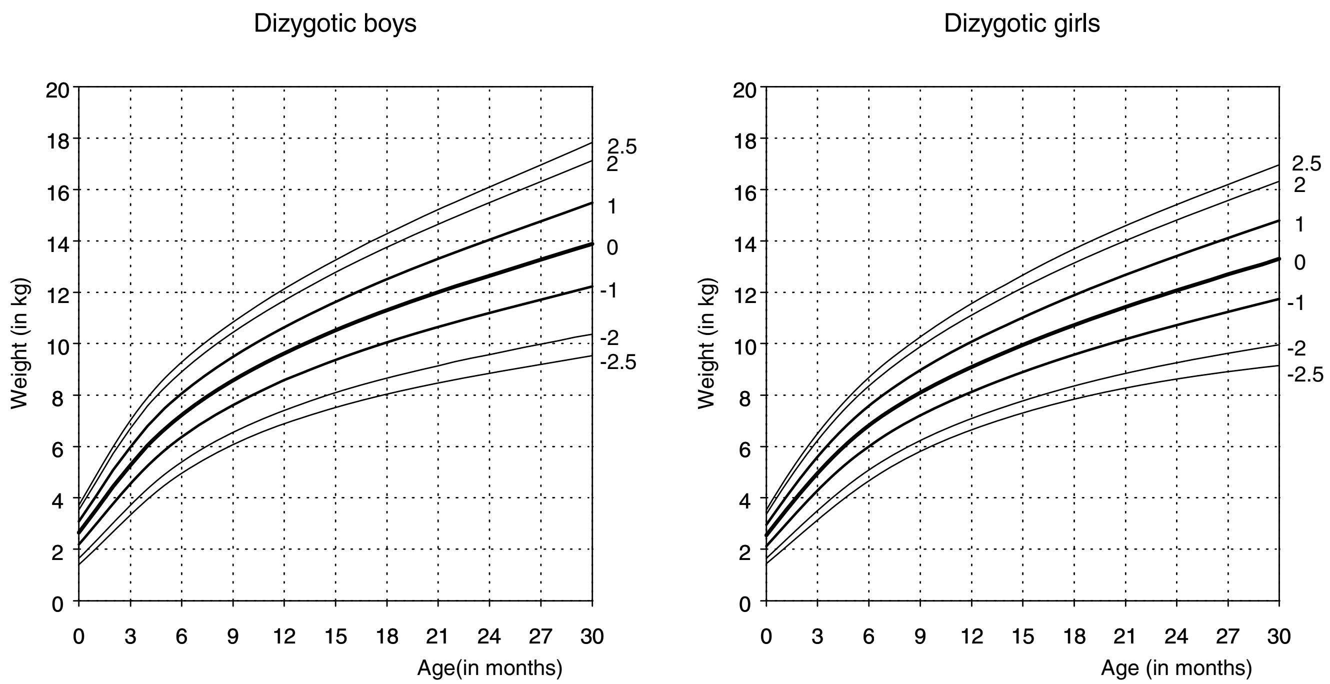

Figure 2 Reference charts for weight of twins in the Netherlands: dizygotic boys and girls from birth to 2.5 years of age; the following curves are shown −2.5 SDS (= P0.6), −2 SDS (= P2), −1 SDS (= P16), 0 SDS (= P50 = median), 1 SDS (= P84), 2 SDS (= P98) and 2.5 SDS (= P99.4).

Table 3 Reference values (LMS) for length/height and weight in monozygotic and dizygotic twins aged 0–30 months

		Monozygotic twins						Dizygotic twins					
		Length/height			Weight			Length/height			Weight		
Sex	Age	L	M	S	L	M	S	L	M	S	L	M	S
Boy	0	5.2	47.61	0.055	1.6	2.51	0.175	4.2	48.21	0.057	1.3	2.65	0.170
	1	5.0	51.20	0.052	1.5	3.44	0.161	4.2	51.72	0.053	1.3	3.55	0.158
	2	4.7	54.71	0.049	1.4	4.36	0.148	4.2	55.18	0.049	1.3	4.44	0.146
	3	4.5	58.03	0.046	1.4	5.23	0.137	4.2	58.47	0.046	1.3	5.29	0.137
	4	4.3	61.03	0.044	1.3	6.00	0.128	4.2	61.43	0.044	1.3	6.03	0.129
	5	4.1	63.64	0.042	1.3	6.66	0.120	4.2	63.99	0.041	1.3	6.67	0.123
	6	3.9	65.90	0.040	1.2	7.22	0.115	4.2	66.18	0.040	1.3	7.23	0.118
	8	3.7	69.58	0.037	1.2	8.14	0.109	4.2	69.71	0.038	1.3	8.16	0.112
	10	3.4	72.55	0.036	1.1	8.91	0.106	4.2	72.62	0.037	1.3	8.94	0.109
	12	3.2	75.13	0.036	1.1	9.58	0.106	4.2	75.25	0.037	1.3	9.63	0.108
	18	2.7	81.96	0.036	0.9	11.26	0.109	4.2	81.98	0.038	1.3	11.30	0.109
	24	2.3	87.80	0.038	0.8	12.56	0.114	4.2	87.91	0.039	1.3	12.65	0.113
	30	1.9	93.08	0.040	0.8	13.67	0.119	4.2	93.56	0.040	1.3	13.89	0.118
Girl	0	5.4	47.37	0.051	1.6	2.45	0.176	3.6	47.53	0.055	1.2	2.54	0.163
	1	5.1	50.71	0.049	1.4	3.30	0.164	3.6	50.95	0.051	1.3	3.38	0.152
	2	4.8	53.95	0.047	1.3	4.13	0.152	3.6	54.24	0.048	1.4	4.20	0.141
	3	4.5	57.02	0.045	1.2	4.91	0.142	3.6	57.33	0.046	1.5	4.96	0.132
	4	4.3	59.83	0.043	1.1	5.60	0.133	3.6	60.12	0.043	1.5	5.66	0.125
	5	4.0	62.31	0.042	1.0	6.22	0.127	3.6	62.58	0.041	1.5	6.27	0.120
	6	3.8	64.48	0.040	0.9	6.76	0.122	3.6	64.72	0.040	1.5	6.81	0.116
	8	3.4	68.10	0.039	0.7	7.67	0.116	3.6	68.31	0.038	1.3	7.71	0.111
	10	3.1	71.07	0.038	0.6	8.41	0.114	3.6	71.31	0.037	1.1	8.45	0.108
	12	2.8	73.72	0.037	0.5	9.04	0.114	3.6	73.98	0.036	1.0	9.09	0.107
	18	2.1	80.63	0.037	0.2	10.64	0.115	3.6	81.04	0.037	0.9	10.73	0.109
	24	1.5	86.70	0.039	0.0	11.96	0.116	3.6	87.02	0.038	1.1	12.07	0.112
	30	1.0	92.24	0.040	−0.3	13.18	0.118	3.6	92.44	0.039	1.4	13.30	0.116

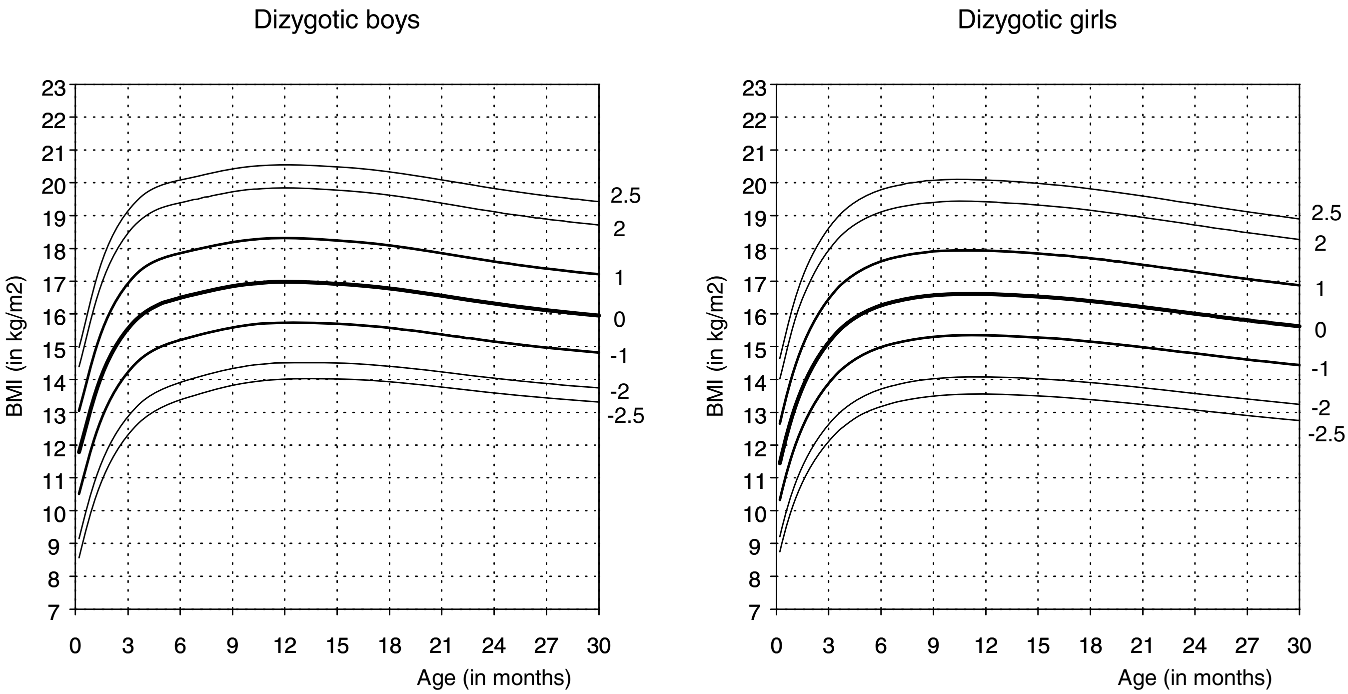

Figure 3 Reference charts for BMI of twins in the Netherlands: dizygotic boys and girls from birth to 2.5 years of age; the following curves are shown −2.5 SDS (= P0.6), −2 SDS (= P2), −1 SDS (= P16), 0 SDS (= P50 = median), 1 SDS (= P84), 2 SDS (= P98) and 2.5 SDS (= P99.4).

Table 4 Reference values (LMS) for BMI for all twins aged 0–30 months

		All twins BMI		
Sex	Age (month)	L	M	S
Boys	0	1.4	11.76	0.124
	1	0.8	13.35	0.098
	2	0.6	14.72	0.091
	3	0.5	15.55	0.088
	4	0.4	16.05	0.085
	5	0.4	16.33	0.082
	6	0.3	16.49	0.081
	8	0.2	16.74	0.078
	10	0.1	16.92	0.077
	12	0.0	16.97	0.076
	18	−0.2	16.78	0.075
	24	−0.3	16.32	0.075
	30	−0.5	15.95	0.075
Girls	0	0.3	11.44	0.122
	1	0.3	13.04	0.093
	2	0.3	14.32	0.088
	3	0.3	15.14	0.085
	4	0.3	15.69	0.083
	5	0.3	16.04	0.082
	6	0.3	16.26	0.081
	8	0.3	16.51	0.079
	10	0.3	16.60	0.079
	12	0.3	16.61	0.078
	18	0.3	16.39	0.078
	24	0.3	16.01	0.078
	30	0.3	15.62	0.078

The difference in BMI between the type of twins was not statistically significant, and we have therefore constructed only one reference chart based on the dizygotic twins (see Fig. 3). The LMS values for BMI are shown in Table 4.

DISCUSSION

Differences in length/height, weight and BMI between twins and singletons decline during the first 2.5 years, but do not disappear completely. Part of these differences remains even after correcting for premature birth. Accordingly, there is a genuine need for special growth charts for twins. This study has developed growth references specifically for twins.

The new growth charts are based on Dutch twins. The WHO Multicentre Growth Study detected only small differences for height and weight in children up to the age of 2 years among different populations (17). It seems likely that this would be similar to twins. Given the large growth deficit in twins during early age, we advise to use twin-specific references rather than reverting to the countries' own reference for singletons with or without correction. We, therefore, recommend the twin references as presented here for application to twins in other populations. For East-Asian countries, we cannot give the same advice as Hur et al. reported that the total phenotypic variances of birthweight were about 45% larger in Caucasians than in East Asians (18). Therefore, East-Asian twins might grow differently than Caucasian twins. Growth charts for Japanese twins are available and we advise to use these for countries in

East Asia (19). No LMS references for Japanese twins were obtained.

The standard reference population dates from 1997(5,6), while the twins in our study were born in the period from 1986 to 1992. In view of the fact that improvements in the availability and quality of food, health and hygiene can lead to an increase in the height-growth rate, various studies have been conducted to identify the difference (5,6,20). These studies show that secular trend only becomes evident later in life. Since 1965, the height of individuals up to 3 years of age has remained virtually unchanged (5). With regard to BMI, in the age group from birth to 2.5 years of age, no more than 13% of the population examined in 1997 passed the P90 for 1980, 54% the P50 and 90% the P10 (6). Furthermore, we examined secular trend between 1988/1989, which is part of the period in which the twin data collection took place, and 1997 by using a reference sample obtained from the Social Medical Survey of Children Attending Child Health Clinics cohort, a nationally representative cohort of 2151 children born in the Netherlands in 1988–1989 (21). For this cohort, mean length, weight and BMI SDS was equal to −0.12, −0.05 and 0.12 for age group <0.5 year, 0.01, −0.04 and −0.01 for age group 0.5–1.4 years, and 0.07, 0.04 and 0.05 for age group 1.5–2.5 years. These results show no systematic trend. Therefore, our results are unlikely to be affected by the differences in birth dates.

During the first 2.5 years of life, differences occur in growth between twins and singletons, even after correcting for gestational age. We recommend the use of reference growth charts for twins.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the valuable suggestions made by the reviewer.

CONTRIBUTORS LIST

Paula van Dommelen: Performed statistical analysis and wrote the manuscript.
Mathisca de Gunst: Initiated the study, provided statistical advice and was involved in all versions of the manuscript.
Aad van der Vaart and Stef van Buuren: Provided statistical advice and were involved in all versions of the manuscript.
Dorret Boomsma: Helped in acquisition of data, initiated the study and was involved in all versions of the manuscript.

CONFLICT OF INTEREST

No.

References

1. Liu YC, Blair EM. Predicted birthweight for singletons and twins. *Twin Res* 2002; 5: 529–37.
2. Bleker OP, Oosting J, Hemrika DJ. On the cause of the retardation of fetal growth in multiple gestations. *Acta Genet Med Gemellol (Roma)* 1988; 37: 41–6.
3. Hennequin Y, Rorive S, Vermeylen D, Pardou A. Twins: interpretation of height-weight curves at birth. *Rev Med Brux* 1999; 20: 81–5.
4. Wilson RS. Twin growth: initial deficit, recovery, and trends in concordance from birth till nine years. *Ann Hum Biol* 1979; 6: 205–20.
5. Fredriks AM, van Buuren S, Burgmeijer RJF, Meulmeester JF, Beuker RJ, Brugman E, et al. Continuing positive secular growth change in the Netherlands 1955–1997. *Pediatric Res* 2000; 47: 316–23.
6. Fredriks AM, van Buuren S, Wit JM, Verloove-Vanhorick SP. Body index measurements in 1996–7 compared with 1980. *Arch Dis Child* 2000; 82: 107–12.
7. Boomsma DI, Orlebeke JF, van Baal GCM. The Dutch Twin Register. Growth data on weight and height. *Behav Genet* 1999; 22: 247–51.
8. Boomsma DI, Vink JM, van Beijsterveldt TC, de Geus EJ, Beem AL, Mulder EJ, et al. Netherlands Twin Register. A focus on longitudinal research. *Twin Res* 2002; 5: 401–6.
9. Boomsma DI, de Geus EJ, Vink JM, Stubbe JH, Distel MA, Hottenga JJ, et al. Netherlands Twin Register: from twins to twin families. *Twin Res Hum Genet* 2006; 9: 849–57.
10. Healy MJ. Reference values and standards for paired organs. *Ann Hum Biol* 1993; 20: 75–6.
11. Cole TJ, Green PJ. Smoothing reference centile curves: the LMS method and penalized likelihood. *Stat Med* 1992; 11: 1305–19.
12. Green PL. Penalized likelihood for general semi-parametric regression models. *Int Stat Rev* 1987; 55: 245–59.
13. van Buuren S, Fredriks M. Worm plot: a simple diagnostic device for modelling growth reference curves. *Stat Med* 2001; 20: 1259–77.
14. Cole TJ, Pan H. *LMS program version 1.16. A program for calculating age-related reference centiles using the LMS method*. London: Institute of Child Health; 2002.
15. Niklasson A, Ericson A, Fryer JG, Karlberg J, Lawrence C, Karlberg P. An update of the Swedish reference standards for weight, length and head circumference at birth for given gestational age (1977–1981). *Acta Paediatr Scand* 1991; 80: 756–62.
16. van Dommelen P, de Gunst MC, Van Der Vaart AW, Boomsma DI. Genetic study of the height and weight process during infancy. *Twin Res* 2004; 7: 607–16.
17. WHO Multicentre Growth Reference Study Group. Assessment of differences in linear growth among populations in the WHO Multicentre Growth Reference Study. *Acta Pediatrica* 450(Suppl.): 56–65.
18. Hur YM, Luciano M, Martin NG, Boomsma DI, Iacono WG, McGue M, et al. A comparison of twin birthweight data from Australia, the Netherlands, the United States, Japan, and South Korea: are genetic and environmental variations in birthweight similar in Caucasians and East Asians? *Twin Res Hum Genet* 2005; 8: 638–48.
19. Ooki S, Yokoyama Y. Physical growth charts from birth to six years of age in Japanese twins. *J Epidemiol* 2003; 13: 333–41.
20. Hauspie RC, Vercauteren M, Susanne C. Secular changes in growth. *Horm Res* 1996; 45(Suppl. 2): 8–17.
21. Herngreen WP, Reerink JD, van Noord-Zaadstra BM, Verloove-Vanhorick SP, Ruys JH. The SMOCC-study: design of a representative cohort of live-born infants in the Netherlands. *Eur J Public Health* 1992; 2: 117–22.